2 Definition and characterization of health-care waste

2.1 Health-care waste: definition and classification

2.1.1 Definition

Health-care waste includes all the waste generated by health-care establishments, research facilities, and laboratories. In addition, it includes the waste originating from "minor" or "scattered" sources—such as that produced in the course of health care undertaken in the home (dialysis, insulin injections, etc.).

Between 75% and 90% of the waste produced by health-care providers is non-risk or "general" health-care waste, comparable to domestic waste. It comes mostly from the administrative and housekeeping functions of health-care establishments and may also include waste generated during maintenance of health-care premises. The remaining 10–25% of health-care waste is regarded as hazardous and may create a variety of health risks (see Chapter 3). This handbook is concerned almost exclusively with hazardous health-care waste (also known as "health-care risk waste"); general wastes should be dealt with by the municipal waste disposal mechanisms.

Classification of hazardous health-care waste is summarized in Table 2.1 and described in more detail in sections 2.1.2 to 2.1.10.

2.1.2 Infectious waste

Infectious waste is suspected to contain pathogens (bacteria, viruses, parasites, or fungi) in sufficient concentration or quantity to cause disease in susceptible hosts. This category includes:

- cultures and stocks of infectious agents from laboratory work;
- waste from surgery and autopsies on patients with infectious diseases (e.g. tissues, and materials or equipment that have been in contact with blood or other body fluids);
- waste from infected patients in isolation wards (e.g. excreta, dressings from infected or surgical wounds, clothes heavily soiled with human blood or other body fluids);
- waste that has been in contact with infected patients undergoing haemodialysis (e.g. dialysis equipment such as tubing and filters, disposable towels, gowns, aprons, gloves, and laboratory coats);
- infected animals from laboratories;
- any other instruments or materials that have been in contact with infected persons or animals.

Note: Infected "sharps" are a subcategory of infectious waste but are dealt with separately in this handbook (see section 2.1.4).

Table 2.1 *Categories of health-care waste*

Waste category	Description and examples
Infectious waste	Waste suspected to contain pathogens e.g. laboratory cultures; waste from isolation wards; tissues (swabs), materials, or equipment that have been in contact with infected patients; excreta
Pathological waste	Human tissues or fluids e.g. body parts; blood and other body fluids; fetuses
Sharps	Sharp waste e.g. needles; infusion sets; scalpels; knives; blades; broken glass
Pharmaceutical waste	Waste containing pharmaceuticals e.g. pharmaceuticals that are expired or no longer needed; items contaminated by or containing pharmaceuticals (bottles, boxes)
Genotoxic waste	Waste containing substances with genotoxic properties e.g. waste containing cytostatic drugs (often used in cancer therapy); genotoxic chemicals
Chemical waste	Waste containing chemical substances e.g. laboratory reagents; film developer; disinfectants that are expired or no longer needed; solvents
Wastes with high content of heavy metals	Batteries; broken thermometers; blood-pressure gauges; etc.
Pressurized containers	Gas cylinders; gas cartridges; aerosol cans
Radioactive waste	Waste containing radioactive substances e.g. unused liquids from radiotherapy or laboratory research; contaminated glassware, packages, or absorbent paper; urine and excreta from patients treated or tested with unsealed radionuclides; sealed sources

Cultures and stocks of highly infectious agents, waste from autopsies, animal bodies, and other waste items that have been inoculated, infected, or in contact with such agents are called **highly infectious waste**.

2.1.3 Pathological waste

Pathological waste consists of tissues, organs, body parts, human fetuses and animal carcasses, blood, and body fluids. Within this category, recognizable human or animal body parts are also called **anatomical waste**. This category should be considered as a subcategory of infectious waste, even though it may also include healthy body parts.

2.1.4 Sharps

Sharps are items that could cause cuts or puncture wounds, including needles, hypodermic needles, scalpel and other blades, knives, infusion sets, saws, broken glass, and nails. Whether or not they are infected, such items are usually considered as highly hazardous health-care waste.

2.1.5 Pharmaceutical waste

Pharmaceutical waste includes expired, unused, spilt, and contaminated pharmaceutical products, drugs, vaccines, and sera that are no longer required and need to be disposed of appropriately. The category also includes discarded items used in the handling of pharmaceuticals, such

as bottles or boxes with residues, gloves, masks, connecting tubing, and drug vials.

2.1.6 Genotoxic waste

Genotoxic waste is highly hazardous and may have mutagenic, teratogenic, or carcinogenic properties. It raises serious safety problems, both inside hospitals and after disposal, and should be given special attention. Genotoxic waste may include certain cytostatic drugs (see below), vomit, urine, or faeces from patients treated with cytostatic drugs, chemicals, and radioactive material.

Cytotoxic (or antineoplastic) drugs, the principal substances in this category, have the ability to kill or stop the growth of certain living cells and are used in chemotherapy of cancer. They play an important role in the therapy of various neoplastic conditions but are also finding wider application as immunosuppressive agents in organ transplantation and in treating various diseases with an immunological basis. Cytotoxic drugs are most often used in specialized departments such as oncology and radiotherapy units, whose main role is cancer treatment; however, their use in other hospital departments is increasing and they may also be used outside the hospital setting.

The most common genotoxic substances used in health care are listed in Box 2.1.

Box 2.1 Most common genotoxic products used in health care[a]

Classified as carcinogenic

Chemicals:
benzene

Cytotoxic and other drugs:
azathioprine, chlorambucil, chlornaphazine, ciclosporin, cyclophosphamide, melphalan, semustine, tamoxifen, thiotepa, treosulfan

Radioactive substances:
(radioactive substances are treated as a separate category in this handbook)

Classified as possibly or probably carcinogenic

Cytotoxic and other drugs:
azacitidine, bleomycin, carmustine, chloramphenicol, chlorozotocin, cisplatin, dacarbazine, daunorubicin, dihydroxymethylfuratrizine (e.g. Panfuran S—no longer in use), doxorubicin, lomustine, methylthiouracil, metronidazole, mitomycin, nafenopin, niridazole, oxazepam, phenacetin, phenobarbital, phenytoin, procarbazine hydrochloride, progesterone, sarcolysin, streptozocin, trichlormethine

[a]Classified by working groups of the International Agency for Research on Cancer (IARC).

Harmful cytostatic drugs can be categorized as follows:

- alkylating agents: cause alkylation of DNA nucleotides, which leads to cross-linking and miscoding of the genetic stock;
- antimetabolites: inhibit the biosynthesis of nucleic acids in the cell;
- mitotic inhibitors: prevent cell replication.

Cytotoxic wastes are generated from several sources and can include the following:

- contaminated materials from drug preparation and administration, such as syringes, needles, gauges, vials, packaging;
- outdated drugs, excess (leftover) solutions, drugs returned from the wards;
- urine, faeces, and vomit from patients, which may contain potentially hazardous amounts of the administered cytostatic drugs or of their metabolites and which should be considered genotoxic for at least 48 hours and sometimes up to 1 week after drug administration.

In specialized oncological hospitals, genotoxic waste (containing cytostatic or radioactive substances) may constitute as much as 1% of the total health-care wastes.

2.1.7 Chemical waste

Chemical waste consists of discarded solid, liquid, and gaseous chemicals, for example from diagnostic and experimental work and from cleaning, housekeeping, and disinfecting procedures. Chemical waste from health care may be hazardous or nonhazardous; in the context of protecting health, it is considered to be hazardous if it has at least one of the following properties:

- toxic;
- corrosive (e.g. acids of pH < 2 and bases of pH > 12);
- flammable;
- reactive (explosive, water-reactive, shock-sensitive);
- genotoxic (e.g. cytostatic drugs).

Nonhazardous chemical waste consists of chemicals with none of the above properties, such as sugars, amino acids, and certain organic and inorganic salts.

The types of hazardous chemicals used most commonly in maintenance of health-care centres and hospitals and the most likely to be found in waste are discussed in the following paragraphs.

Formaldehyde
Formaldehyde is a significant source of chemical waste in hospitals. It is used to clean and disinfect equipment (e.g. haemodialysis or surgical equipment), to preserve specimens, to disinfect liquid infectious waste, and in pathology, autopsy, dialysis, embalming, and nursing units.

Photographic chemicals
Photographic fixing and developing solutions are used in X-ray departments. The fixer usually contains 5–10% hydroquinone, 1–5% potassium hydroxide, and less than 1% silver. The developer contains approxi-

mately 45% glutaraldehyde. Acetic acid is used in both stop baths and fixer solutions.

Solvents
Wastes containing solvents are generated in various departments of a hospital, including pathology and histology laboratories and engineering departments. Solvents used in hospitals include halogenated compounds, such as methylene chloride, chloroform, trichloroethylene, and refrigerants, and non-halogenated compounds such as xylene, methanol, acetone, isopropanol, toluene, ethyl acetate, and acetonitrile.

Organic chemicals
Waste organic chemicals generated in health-care facilities include:

- disinfecting and cleaning solutions such as phenol-based chemicals used for scrubbing floors, perchlorethylene used in workshops and laundries;
- oils such as vacuum-pump oils, used engine oil from vehicles (particularly if there is a vehicle service station on the hospital premises);
- insecticides, rodenticides.

Inorganic chemicals
Waste inorganic chemicals consist mainly of acids and alkalis (e.g. sulfuric, hydrochloric, nitric, and chromic acids, sodium hydroxide and ammonia solutions). They also include oxidants, such as potassium permanganate ($KMnO_4$) and potassium dichromate ($K_2Cr_2O_7$), and reducing agents, such as sodium bisulfite ($NaHSO_3$) and sodium sulfite (Na_2SO_3).

2.1.8 Wastes with high content of heavy metals

Wastes with a high heavy-metal content represent a subcategory of hazardous chemical waste, and are usually highly toxic. Mercury wastes are typically generated by spillage from broken clinical equipment but their volume is decreasing with the substitution of solid-state electronic sensing instruments (thermometers, blood-pressure gauges, etc.). Whenever possible, spilled drops of mercury should be recovered. Residues from dentistry have a high mercury content. Cadmium waste comes mainly from discarded batteries. Certain "reinforced wood panels" containing lead are still used in radiation proofing of X-ray and diagnostic departments. A number of drugs contain arsenic, but these are treated here as pharmaceutical waste.

2.1.9 Pressurized containers

Many types of gas are used in health care (see Box 2.2), and are often stored in pressurized cylinders, cartridges, and aerosol cans. Many of these, once empty or of no further use (although they may still contain residues), are reusable, but certain types—notably aerosol cans—must be disposed of.

Whether inert or potentially harmful, gases in pressurized containers should always be handled with care; containers may explode if incinerated or accidentally punctured.

Box 2.2 Most common gases used in health care

Anaesthetic gases:
nitrous oxide, volatile halogenated hydrocarbons (such as halothane, isoflurane, and enflurane), which have largely replaced ether and chloroform.

Applications—in hospital operating theatres, during childbirth in maternity hospitals, in ambulances, in general hospital wards during painful procedures, in dentistry, for sedation, etc.

Ethylene oxide
Applications—for sterilization of surgical equipment and medical devices, in central supply areas, and, at times, in operating rooms.

Oxygen
Stored in bulk tank or cylinders, in gaseous or liquid form, or supplied by central piping.

Application—inhalation supply for patients.

Compressed air
Applications—in laboratory work, inhalation therapy equipment, maintenance equipment, and environmental control systems.

2.1.10 Radioactive waste

Background on radioactivity
Ionizing radiations cannot be detected by any of the senses and—other than burns, which may occur in exposed areas—usually cause no immediate effects unless an individual receives a very high dose. The ionizing radiations of interest in medicine include the X-rays, α- and β-particles, and γ-rays emitted by radioactive substances. An important practical difference between these types of radiation is that X-rays from X-ray tubes are emitted only when generating equipment is switched on, whereas radiation from radionuclides can never be switched off and can be avoided only by shielding the material.

Radionuclides continuously undergo spontaneous disintegration (known as "radioactive decay") in which energy is liberated, generally resulting in the formation of new nuclides. The process is accompanied by the emission of one or more types of radiation, such as α- and β-particles and γ-rays. These cause ionization of intracellular material; radioactive substances are therefore genotoxic.

- *α-Particles* are heavy, positively charged, and include protons and neutrons. They have a low penetration power, and are hazardous to humans mostly when inhaled or ingested.
- *β-Particles* are negatively or positively charged electrons with significant ability to penetrate human skin; they affect health through ionization of intracellular proteins and proteinaceous components.
- *γ-Rays* are electromagnetic radiations similar to X-rays but of shorter wavelength. Their penetrating power is high and lead (or thick concrete) shielding is required to reduce their intensity.

Disintegration is measured in terms of the time required for the radioactivity to decrease by half—the "half-life". Each radionuclide has a characteristic half-life, which is constant and by which it may be identified. Half-lives range from fractions of a second to millions of years. Values for the most common radionuclides used in nuclear medicine are listed in Table 2.2.

The *activity* of a radioactive substance corresponds to the disintegration rate and is measured in becquerels (Bq), the SI unit that has replaced the curie (Ci):

1 Bq = 1 disintegration per second
$1\,Ci = 3.7 \times 10^{10}\,Bq$

The amount of energy absorbed, per unit mass, as a result of exposure to ionizing radiation is called the *absorbed dose* and is expressed in gray (Gy); this SI unit has replaced the rad (1 Gy = 100 rad). However, different types of radiation have different effects according to the biological material and the type of tissue. To allow for these differences, absorbed dose is averaged over an organ or tissue and "weighted" for the type of radiation. This yields the *equivalent dose*, measured in sievert (Sv), which replaces the rem (1 Sv = 100 rem).

Radioactive substances used in health care and generating waste

Radioactive waste includes solid, liquid, and gaseous materials contaminated with radionuclides. It is produced as a result of procedures such as *in-vitro* analysis of body tissue and fluid, *in-vivo* organ imaging and tumour localization, and various investigative and therapeutic practices.

Table 2.2 *Principal radionuclides used in health-care establishments*[a]

Radionuclide[b]	Emission	Format	Half-life	Application
^{3}H	β	Unsealed	12.3 years	Research
^{14}C	β	Unsealed	5730 years	Research
^{32}P	β	Unsealed	14.3 days	Diagnosis; therapy
^{51}Cr	γ	Unsealed	27.8 days	*In-vitro* diagnosis
^{57}Co	β	Unsealed	271 days	*In-vitro* diagnosis
^{60}Co	β	Sealed	5.3 years	Diagnosis; therapy; research
^{59}Fe	β	Unsealed	45 days	*In-vitro* diagnosis
^{67}Ga	γ	Unsealed	78 hours	Diagnostic imaging
^{75}Se	γ	Unsealed	119 days	Diagnostic imaging
^{85}Kr	β	Unsealed	10.7 years	Diagnostic imaging; research
^{99m}Tc	γ	Unsealed	6 hours	Diagnostic imaging
^{123}I	γ	Unsealed	13.1 hours	Diagnostic uptake; therapy
^{125}I	γ	Unsealed	60 days	Diagnostic uptake; therapy
^{131}I	β	Unsealed	8 days	Therapy
^{133}Xe	β	Unsealed	5.3 days	Diagnostic imaging
^{137}Cs	β	Sealed	30 years	Therapy; research
^{192}Ir	β	Sealed (ribbons)	74 days	Therapy
^{198}Au	β	Sealed (seeds)	2.3 days	Therapy
^{222}Rd	α	Sealed (seeds)	3.8 days	Therapy
^{226}Ra	α	Sealed	1600 years	Therapy

[a] Adapted from WHO (1985).
[b] ^{3}H and ^{14}C used for research purposes account for the largest amount of radioactive health-care waste.

Radionuclides used in health care are usually conditioned in unsealed (or "open") sources or sealed sources. Unsealed sources are usually liquids that are applied directly and not encapsulated during use; sealed sources are radioactive substances contained in parts of equipment or apparatus or encapsulated in unbreakable or impervious objects such as "seeds" or needles.

Radioactive health-care waste usually contains radionuclides with short half-lives, which lose their activity relatively quickly (see Table 2.2). Certain therapeutic procedures, however, require the use of radionuclides with longer half-lives; these are usually in the form of pins, needles, or "seeds" and may be reused on other patients after sterilization.

The type and form of radioactive material used in health-care establishments usually results in low-level radioactive waste (<1 MBq). Waste in the form of sealed sources may be of fairly high activity, but is only generated in low volumes from larger medical and research laboratories. Sealed sources are generally returned to the supplier and so do not enter the waste stream. The principal activities involving use of radioactive substances, and the waste they generate, are described in Box 2.3. The most common radionuclides used in diagnostic nuclear medicine and the maximum activity per diagnostic test are listed in Annex 1.

The waste produced by health-care and research activities involving radionuclides, and related activities such as equipment maintenance, storage, etc., can be classified as follows:

- sealed sources;
- spent radionuclide generators;
- low-level solid waste, e.g. absorbent paper, swabs, glassware, syringes, vials;
- residues from shipments of radioactive material and unwanted solutions of radionuclides intended for diagnostic or therapeutic use;
- liquid immiscible with water, such as liquid scintillation-counting residues used in radioimmunoassay, and contaminated pump oil;
- waste from spills and from decontamination of radioactive spills;
- excreta from patients treated or tested with unsealed radionuclides;
- low-level liquid waste, e.g. from washing apparatus;
- gases and exhausts from stores and fume cupboards.

2.2 Sources of health-care waste

The sources of health-care waste can be classed as major or minor according to the quantities produced. The major sources are listed in Box 2.4.

While minor and scattered sources may produce some health-care waste in categories similar to hospital waste, their composition will be different. For example:

- they rarely produce radioactive or cytostatic waste;
- human body parts are generally not included;
- sharps consist mainly of hypodermic needles.

Minor sources of health-care waste are listed in Box 2.5.

Box 2.3 Health care and research involving radionuclides, and waste produced

Nuclear medicine laboratories

Unsealed sources
Diagnostic procedures (organ imaging, tumour localization): use preparations with activities up to 800 MBq (or even 6000 MBq for certain lung-imaging techniques) and short half-life. Over 90% of diagnostic nuclear medicine applications use ^{99m}Tc.

Therapeutic applications (radiotherapy): use preparations of ^{32}P, ^{125}I and ^{131}I, which are of a much higher level of activity. However, these applications are infrequent. They are used in the activity range of up to 1 GBq to treat hyperthyroidism and up to 10 GBq to treat thyroid carcinoma.

Generated waste: glassware, syringes, absorbent paper, solutions, excreta from patients treated or tested with unsealed radionuclides. Waste from diagnostic procedures is usually low-level; wastes from therapeutic applications, however, may be relatively high-level. All radionuclides used have relatively short half-lives (between 6 hours and 60 days).

Sealed sources
Therapeutic applications: use sealed sources that generally involve radionuclides with high activity levels and long half-lives (e.g. cobalt, caesium). In teletherapy the source is comparatively distant from the patient's body; brachytherapy usually employs small sources to deliver doses at distances up to a few centimetres, by surface, intracavitary, or interstitial application.

Generated waste: these activities do not routinely generate radioactive waste. Sources should be reused as long as is feasible, or returned to the supplier when exhausted or no longer required.

Research laboratories

Generated waste: significant quantities of ^{14}C and ^{3}H (both with long half-lives) are used in research activities, which therefore generate large volumes of waste with low activity.

Clinical laboratories

Generated waste: laboratories involved in radioimmunoassay produce relatively large volumes of waste with low radioactivity, including gases (e.g. ^{85}Kr, ^{133}Xe).

The composition of wastes is often characteristic of the type of source. For example, the different units within a hospital would generate waste with the following characteristics:

- *Medical wards*: mainly infectious waste such as dressings, bandages, sticking plaster, gloves, disposable medical items, used hypodermic needles and intravenous sets, body fluids and excreta, contaminated packaging, and meal scraps.
- *Operating theatres and surgical wards*: mainly anatomical waste such as tissues, organs, fetuses, and body parts, other infectious waste, and sharps.

Box 2.4 Major sources of health-care waste

Hospitals
— University hospital
— General hospital
— District hospital

Other health-care establishments
— Emergency medical care services
— Health-care centres and dispensaries
— Obstetric and maternity clinics
— Outpatient clinics
— Dialysis centres
— First-aid posts and sick bays
— Long-term health-care establishments and hospices
— Transfusion centres
— Military medical services

Related laboratories and research centres
— Medical and biomedical laboratories
— Biotechnology laboratories and institutions
— Medical research centres

Mortuary and autopsy centres

Animal research and testing

Blood banks and blood collection services

Nursing homes for the elderly

- *Other health-care units*: mostly general waste with a small percentage of infectious waste.
- *Laboratories*: mainly pathological (including some anatomical), highly infectious waste (small pieces of tissue, microbiological cultures, stocks of infectious agents, infected animal carcasses, blood and other body fluids), and sharps, plus some radioactive and chemical waste.
- *Pharmaceutical and chemical stores*: small quantities of pharmaceutical and chemical wastes, mainly packaging (containing only residues if stores are well managed), and general waste.
- *Support units*: general waste only.

Health-care waste from scattered sources generally has the following characteristic composition:

- *Health care provided by nurses*: mainly infectious waste and many sharps.
- *Physicians' offices*: mainly infectious waste and some sharps.
- *Dental clinics and dentists' offices*: mainly infectious waste and sharps, and wastes with high heavy-metal content.
- *Home health care* (e.g. dialysis, insulin injections): mainly infectious waste and sharps.

Box 2.5 Minor sources of health-care waste

Small health-care establishments
— Physicians' offices
— Dental clinics
— Acupuncturists
— Chiropractors

Specialized health-care establishments and institutions with low waste generation
— Convalescent nursing homes
— Psychiatric hospitals
— Disabled persons' institutions

Non-health activities involving intravenous or subcutaneous interventions
— Cosmetic ear-piercing and tattoo parlours
— Illicit drug users

Funeral services

Ambulance services

Home treatment

2.3 Health-care waste generation

Several surveys have provided an indication of typical health-care waste generation. Data from some of these surveys are summarized in Tables 2.3 to 2.6 and show that generation of health-care wastes differs not only from country to country but also within a country. Waste generation depends on numerous factors such as established waste management methods, type of health-care establishment, hospital specializations, proportion of reusable items employed in health care, and proportion of patients treated on a day-care basis. It is therefore suggested that these data are viewed only as examples, and not used as a basis for waste management within an individual health-care establishment. Even a limited survey will probably provide more reliable data on local waste generation than any estimate based on data from other countries or types of establishment.

In middle- and low-income countries, health-care waste generation is usually lower than in high-income countries. However, the range of values for countries of similar income level is probably as wide in high-income countries (Table 2.4) as in less wealthy countries.

The amount of radioactive health-care waste is generally extremely small compared with the radioactive waste produced by the nuclear industry.

Developing countries that have not performed their own surveys of health-care waste may find the following estimates for average

Table 2.3 Health-care waste generation according to national income level[a]

National income level	Annual waste generation (kg/head of population)
High-income countries:	
— all health-care waste	1.1–12.0
— hazardous health-care waste	0.4–5.5
Middle-income countries:	
— all health-care waste	0.8–6.0
— hazardous health-care waste	0.3–0.4
Low-income countries:	
— all health-care waste	0.5–3.0

[a]Sources: Commission of the European Union (1995), Halbwachs (1994), Durand (1995).

Table 2.4 Health-care waste generation according to source size[a]

Source	Daily waste generation[b] (kg/bed)
University hospital	4.1–8.7
General hospital	2.1–4.2
District hospital	0.5–1.8
Primary health-care centre	0.05–0.2

[a]Source: Economopoulos (1993).
[b]Data from high-income countries.

Table 2.5 Total health-care waste generation by region[a]

Region	Daily waste generation (kg/bed)
North America	7–10
Western Europe	3–6
Latin America	3
Eastern Asia:	
— high-income countries	2.5–4
— middle-income countries	1.8–2.2
Eastern Europe	1.4–2
Eastern Mediterranean	1.3–3

[a]Sources: Durand (personal communication, 1995), Johannessen (1997). Further information may be obtained from International Healthcare Waste Network, 12–14 avenue Paul Vaillant Couturier, 94804 Villejuif, France.

Table 2.6 Hospital waste generation by waste type (western Europe)[a]

Waste class	Daily waste generation (kg/bed)
Chemical and pharmaceutical waste	0.5
Sharps	0.04
Combustible packaging	0.5

[a]Source: Durand (personal communication, 1995). Further information may be obtained from International Healthcare Waste Network, 12–14 avenue Paul Vaillant Couturier, 94804 Villejuif, France.

distribution of health-care wastes useful for *preliminary* planning of waste management:

- 80% general health-care waste, which may be dealt with by the normal domestic and urban waste management system;
- 15% pathological and infectious waste;
- 1% sharps waste;
- 3% chemical or pharmaceutical waste;
- less than 1% special waste, such as radioactive or cytostatic waste, pressurized containers, or broken thermometers and used batteries.

Before further planning is undertaken, health-care establishments should make estimates of their own waste production, particularly for hazardous health-care wastes. Typical figures for small producers of health-care wastes in Europe are given in Table 2.7.

A survey carried out in selected countries in Latin America and the Caribbean provides estimates of hazardous waste produced by health-care facilities; data are summarized in Box 2.6. Boxes 2.7 and 2.8 contain data on health-care wastes generated in the United Republic of Tanzania and in Botswana.

2.4 Physicochemical characteristics of hazardous health-care waste

When the use of treatment techniques such as incineration is planned, a number of physicochemical parameters of the waste should be assessed

Table 2.7 *Health-care waste generation for small waste generators (Europe)*[a]

Source type	Waste generation (kg/year)
General practitioners:	
— sharps	4
— infectious waste	20
— total waste	100
Phlebotomists:	
— infectious waste	175
Gynaecologists:	
— infectious waste	350
Nurses:	
— sharps	20
— infectious waste	100
Dentists:	
— sharps	11
— infectious waste	50
— heavy metals (including mercury)	2.5
— total waste	260
Biomedical laboratories (60 analyses per day):	at least 300
— infectious waste	
Kidney dialysis (3 per week):	
— infectious waste	400

[a]Source: Durand (personal communication, 1995). Further information may be obtained from International Healthcare Waste Network, 12–14 avenue Paul Vaillant Couturier, 94804 Villejuif, France.

Box 2.6 Hazardous health-care waste quantities produced in health-care facilities in selected countries of Latin America and the Caribbean[a]

Country	Number of beds	Hazardous waste generation[b] (tonnes/year)
Argentina	150 000	32 850
Brazil	501 660	109 960
Cuba	50 293	11 010
Jamaica	5 745	1 260
Mexico	60 100	13 160
Venezuela	47 200	10 340

[a]Source: PAHO (1994), used with permission.
[b]These estimates are based on 0.22 tonnes/year for each bed in a health-care establishment.

Box 2.7 Health-care waste generation in government health facilities of Dar es Salaam (United Republic of Tanzania)[a]

Health-care facility	Health-care waste quantities in 1995/1996[b]	
	Non-hazardous waste (kg/day per patient)	Hazardous waste (kg/day per patient)
District hospital (in- and outpatients)	0.06	0.08
Health centres (urban)	0.01	0.01
Dispensaries:		
— rural	0.02	0.02
— urban	0.01	0.01

[a]Source: Christen (1996), used with permission.
[b]Average quantities estimated on the basis of a survey conducted in a representative number of health-care establishments in Dar es Salaam.

or estimated.[1] Table 2.8 provides typical figures for percentage of combustibles, heating value, and moisture content of waste. It is also important to assess the composition of waste, which varies greatly not only from country to country but also among facilities within any given country. This variation may be due to different hospital specializations, waste management practices, use of reusable items, etc. As examples, Boxes 2.9, 2.10, and 2.11 contain data from surveys in Italy, China (Province of

[1] Instructions on the estimation of several of these parameters may be found in WHO–CEPIS (1994), Annex 2. An English version of this document was planned when the text of the present handbook was finalized.

Table 2.8 Physical parameters

Parameter	Minimum value	Maximum value	Average value
Percentage of combustible matter	83%	99%	—
Low heating value	3000 kcal/kg (12 550 kJ/kg)	6000 kcal/kg (25 100 kJ/kg)	—
Moisture content	0% (for plastic waste)	90% (for some anatomical waste)	35%

Box 2.8 Estimated health-care waste production in Botswana[a,b]

Facility	Health-care waste, excluding sharps (kg/day)	Sharps (containers[c])	Household waste (kg/day)
Referral and regional hospitals	0.75/bed	1.5/100 beds per day	3/bed
Private hospitals	1.0/bed	2/100 beds per day	4/bed
Primary hospitals	0.5/bed	1/100 beds per day	2/bed
Urban clinics with beds	20	2/30 days	40
Rural clinics with beds	10	2/30 days	20
Urban clinics	15	2/30 days	30
Rural clinics	7	2/30 days	15
Health posts	2.5	1/30 days	5
Medical and veterinary practices	2.5	1/30 days	5

[a]Source: NCSA (1996, plus personal communication); used with permission.
[b]These data were estimated on the basis of questionnaires sent to health-care facilities and subsequent visits, in 1995–1998.
[c]Sharps container capacity: 4 litres.

Box 2.9 Average composition of hospital waste in Italy

The data below are derived from a survey conducted in a large hospital in southern Italy in 1992 (Liberti et al., 1994).

Material	Percentage (wet-weight basis)
Paper	34
Plastics	46
Glass	7.5
Metals	0.4
Anatomical waste	0.1
Liquids	12
Others	0.1

Box 2.10 Composition of waste from three hospitals in Taiwan, China[a]

	Percentage (by weight)		
Material	University hospital	Hospital A	Hospital B
Paper	16	34	51
Plastics	50	21	18
Textiles	10	14	2
Food waste	21	17	7
Metals (sharps etc.)	0.5	1	9
Glass	1	11	8
Others	1.5	2	5

[a]Source: Chih-Shan & Fu-Tien (1993), used with permission.

Box 2.11 Average composition of hospital waste in India[a]

The data below are average values obtained from 10 large hospitals in Bombay, Calcutta, Delhi, and Nagpur during the period 1993–1996.

Material	Percentage (wet-weight basis)
Paper	15
Plastics	10
Rags	15
Metals (sharps, etc.)	1
Infectious waste	1.5
Glass	4.0
General waste (food waste, sweepings from hospital premises)	53.5

[a]Source: National Environmental Engineering Research Institute (personal communication, 1997).

Taiwan), and India, respectively. A survey of general hospitals in Italy yielded characterization data for hazardous health-care waste; these data are summarized in Box 2.12. A typical low heating value of wet hazardous health-care waste in middle-income developing countries would be 3500 kcal/kg (14.65 MJ/kg).

The approximate chemical composition of general health-care waste is usually as follows:

- 50% carbon
- 20% oxygen
- 6% hydrogen
- numerous other elements.

Box 2.12 Hazardous health-care waste characterization data

The following data are derived from a survey performed in several Italian general hospitals of different size (Liberti et al., 1994). They are based on daily waste production of 4.0 litres or 0.44 kg per bed in use.

Density:	0.11 kg/litre
Heating value:	
high:	dry waste 5400 kcal/kg (22.6 MJ/kg)
	wet waste 3900 kcal/kg (16.3 MJ/kg)
low:	wet waste 3500 kcal/kg (14.65 MJ/kg)
Chlorine content:	0.4%
Mercury content:	2.5 mg/kg
Cadmium content:	1.5 mg/kg
Lead content:	28 mg/kg

Assessing the type of plastic used in health-care activities, and if possible the percentage of halogenated plastics (such as polyvinyl chloride), would indicate the cleaning requirements for exhaust gases if waste is incinerated. Certain types of plastics are now frequently labelled with internationally recognized symbols to facilitate identification of halogenated plastics.

References and suggested further reading

Chih-Shan L, Fu-Tien J (1993). Physical and chemical composition of hospital waste. *Infection control and hospital epidemiology*, 14(3):145–150.

Christen J (1996). *Dar es Salaam Urban Health Project. Health care waste management in district health facilities: situational analysis and system development*. St. Gallen, Switzerland, Swiss Centre for Development Cooperation in Technology and Management (SKAT).

Economopoulos AP (1993). *Assessment of sources of air, water and land pollution. A guide to rapid source inventory techniques and their use in formulating environmental control strategies. Part 1: Rapid inventory techniques in environmental pollution*. Geneva, World Health Organization.

Halbwachs H (1994). Solid waste disposal in district health facilities. *World health forum*, 15:363–367.

Johannessen LM (1997). Management of health care waste. In: *Proceedings in Environment '97 Conference, 16–18 February 1997, Cairo*. Dokki-Giza, Egyptian Environmental Affairs Agency.

Liberti L et al. (1994). Optimization of infectious hospital waste management in Italy. Part I: Waste production and characterization study. *Waste management and research*, 12(5): 373–385.

NCSA (1996). *Study on the management of medical wastes.* Gaborone, Botswana, National Conservation Strategy (Co-ordinating) Agency (Report No. NCS/GTZ 7/96, in cooperation with the German Agency for Technical Cooperation, coordinated by Integrated Skills Ltd).

PAHO (1994). *Hazardous waste and health in Latin America and the Caribbean*. Washington, DC, Pan American Health Organization.

WHO (1985). *Management of waste from hospitals and other health care establishments. Report on a WHO meeting, Bergen, 28 June–1 July 1983*. Copenhagen, World Health Organization Regional Office for Europe (EURO Reports and Studies, No. 97).

WHO/CEPIS (1994). *Guìa para el manejo interno de residuos sòlidos hospitalarios. [Guide to the internal management of solid hospital waste.]* Lima, World Health Organization/Pan American Sanitary Engineering and Environmental Sciences Center.